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CHANGES IN SALINITY AND LANDINGS OF SIX FISH SPECIES IN THE SHELF, NORTH TO THE NILE DELTA

By

M. L. E. El-Hehyawi

Institute of Oceanography and Fisheries, Alexandria, A.R.E.

Abstract

The substantially decreased water discharge of the Nile River into the Mediterranean Sea in the recent years resulted, a marked increase of the salt content in the upper layers of water (the range of salinity 38.86–39.40‰) over the shelf areas close to the delta. The upper 0–50m water layers attained values of σ_t (Sigma-t) which changed from 20.00–25.00 in the years 1900–1971. Simultane usly, profound changes were observed, based on the commercial fish landings, in the abundance of fish species in the same area. While the species like *Sciaena aquilla*, *Solea vulgaris* and *Epinephelus gigas* were negative affected in tneir abundace, other species, belonging to the families *Mullidae*, *Pagridae* and *Triglidae*, became more numerous. It is probable that these changes are associated, above all, with the tolerance or affinity of the young life stages of fishes towards the new salinity values.

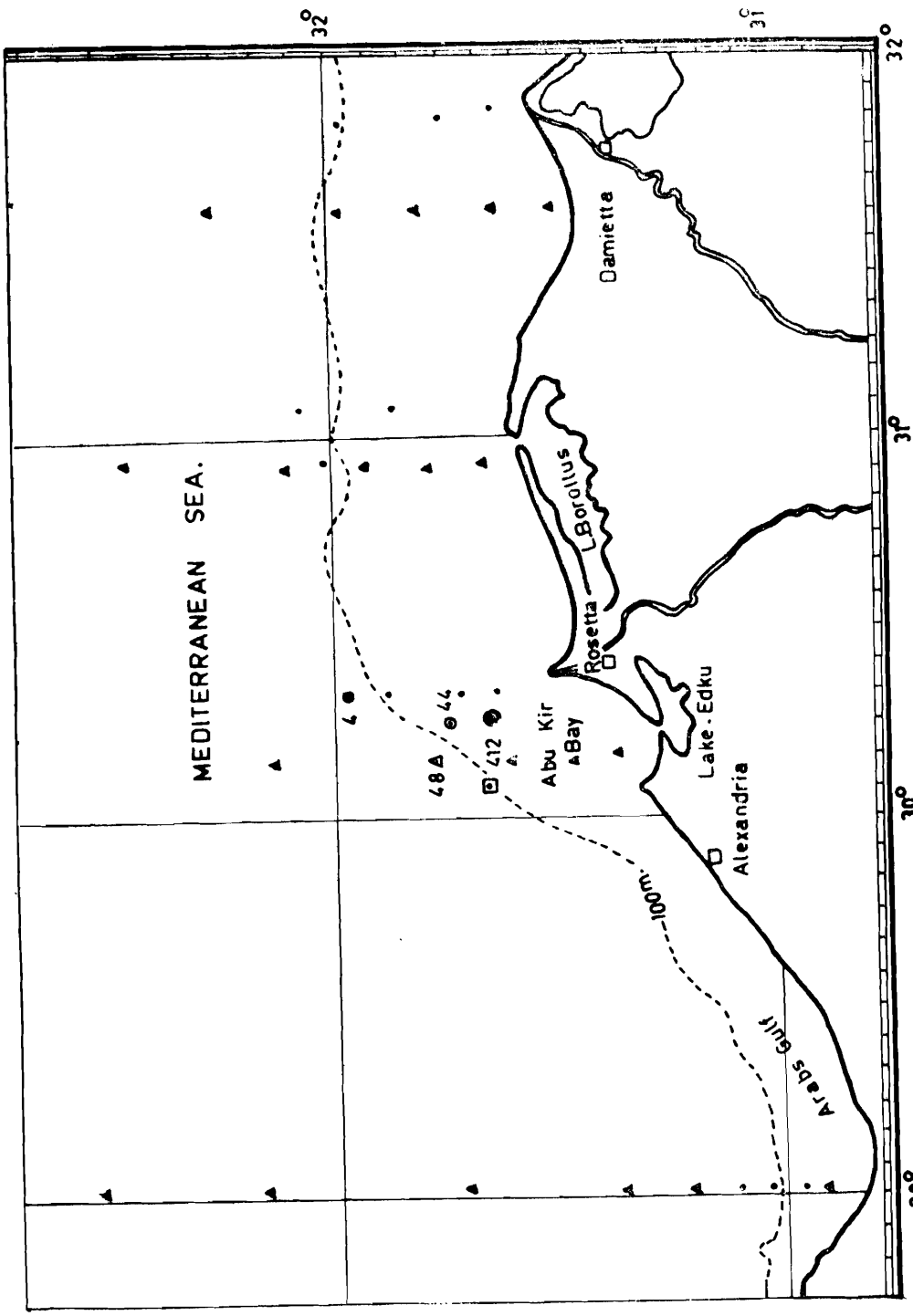
INTRODUCTION

The distribution and abundance of the commercial fishes, especially in the coastal waters, almost depends upon their capability to adapt themselves to the variable environmental conditions. Temperature fluctuations and its effects upon the fishery grounds is ferquently investigated. The slight changes in the salinity of the open sea and oceanic waters were seldom noticed to be beyond the lethal limits.

The variations of the salinity in the coastal regions could be injuriously effective upon the fish populations and need a study to help the prediction of such effects. Lethal effects may result from an abrupt change of the salt content of the surrounding waters beyond certain limits. Recently, the stenohaline proper marine fishes are the element which can penetrate into relatively greater space of the continental shelf regions and the shallow waters of Mediterranean Egyptian coasts. On the other hand, the distribution of the less saline or brackish water fishes decreased because of the regional hydrological changes, which took place after the construction of the high dam.

Relations between the environmental factors including salinity and some fishes are observed in other parts of the oceans. Clear relation, between the salinity and skipjack tuna landings, was found by Seckol & Waldron (1960). Carruthers *et al.*, (1951) have found several associations between various landings of fish broods and the water movements set up by the local winds.

The effect of the physical and chemical characteristics of the water masses upon the egg and larval stages is undoubtedly important in determining the abundance of fish and the distribution of its populations. Some hydrological changes, especially the displacement phenomena of the water masses, are


32°
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MEDITERRANEAN SEA.
Damietta
L. Borollus
Rosetta
Abu Kir
Bay
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Alexandria
100m.
Arabs Gulf
48
44
412

found to have significant effect upon the survival rates of the eggs and larvae. These changes may result in a decrease reaching about 98 % of the abundance of the early stages of fishes as compared with its abundance under the normal conditions (El-Sayed, 1968). The human interference in the hydrological conditions of the coastal waters and the resulting effects upon the fishery grounds is, therefore, of particular importance to the management of the food resources. The changes which took place in the Egyptian Mediterranean waters may help to clarify such effects.

Material and Methods

The salinity and σ_t (Sigma-t) values recorded from the surveys of continental shelf regions North to the delta during 1960-1961 cruises of the research boat "Faras El-bahr" are utilized in this work. The observations taken during the USSR. R/V "Ichthyolog" expeditions in the waters of the south east Mediterranean regions were helpful. The salinity and σ_t (Sigma-t) values taken during 1964, 1966 and 1970 cruises of the "Ichthyolog" were based upon the analysis of seasonally collected samples from the stations of 6 sections. Each section represent 3 to 7 stations. During autumn 1964, 1966 and 1970, the total number of samples collected for the determination of salinity and temperature were about 171, 252 and 314 successively. The sections taken North to Rosetta outlet are more or less helpful in representing the hydrological conditions of the nearshore regions to the delta coasts. The data from the reference stations:

Table 1.

Stn No.	Date	Lat.	Long.
44	19/10/1960	31 45 N	30 15 E
4	12/10/1964	31 52 N	30 19 E
412	19/11/1966	31 36 N	30 04 E
48	17/9/1970	31 64 N	30 10 E

in table. (1) facilittated to construct the schematic figures (2 A, B) showing the change in salinity and density isolines during the corresponding months of successive 1960-1971 years.

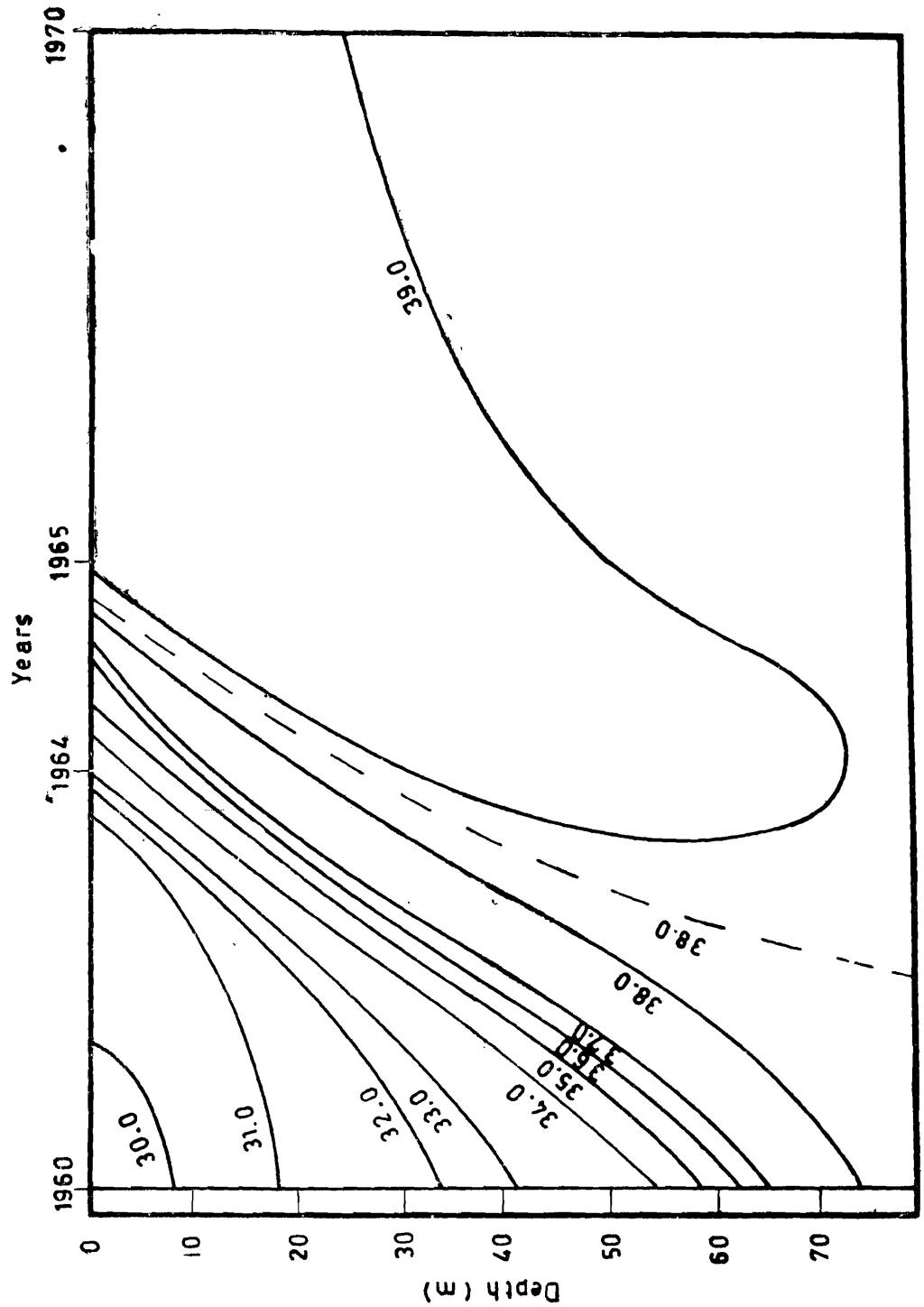

FIG. 2 (*a*). The distribution of salinity isolines with depth in the region 20–30 miles North to the Rosetta outlet during autumn 1960, 1964, 1966 and 1971.

The figures help also in the identification of the influence of the Nile discharge upon the prevailing water bodies in the main coastal fishery grounds during the autumn seasons of this period. Other results of chemical analysis of surface samples collected during 1963, from 4 stations located at equal distances of one kilometer from Lake Edku outlet, are also used. In November 1971, 3 experiments of fishing by beach seine were performed along the southern shores of Abu-Kir Bay and west to Edku Lake-sea connection. The results of these experiments plus the results of chemical analysis of 6 surface water samples taken from the corresponding shore waters, were utilized.

Different data from other environments in other seas are taken into consideration. Benefit is taken also from some observations performed in the north western part of the Bladk Sea during the years 1966, 1967. The literature cited provide some data which facilitate the analysis.

Statistics of fish landings in the years 1962-1969 from the annual reports on the fisheries of the U.A.R. were used. Combination of the profiles showing the isolines of salinity and density distribution during the years 1960-1971, in the regions about 25-30 miles north to the Rosetta estuary, along with the curves of total annual fish catches, were helpful to trace the effects of the recent hydrological changes upon the fishes which have pelagic egg and larval stages. The stated annual fish catches are the sum taken in all the regions and water masses North to the Nile delta at the year of capture (the upper scale of the figures 3-6).

General account of the salinity changes (North to the Nile Delta)

As indicated by Halim *et al.*, (1967) the outflowing Nile waters was observed before 1965 to reach the regions at about 50 miles north to the Rosetta outlet. A change in the hydrological characteristics could also be traced by the calculation of the difference between the average annual outflowing Nile water in the period before the year 1962 and the average outflow during the years 1962-1964. This average before 1962 was estimated to be 62 km^3. In 1962, 1963, 1964 and 1965, the annual outflowing river waters was about 44, 44, 63 and 39 km^3, respectively. This change was detectable especially during the flood season in September, October and November : and reached its maximum in October. The discharged water decreased abruptly from 11.3 km^3 in 1966 to 4.1 km^3 in the following years. The east-

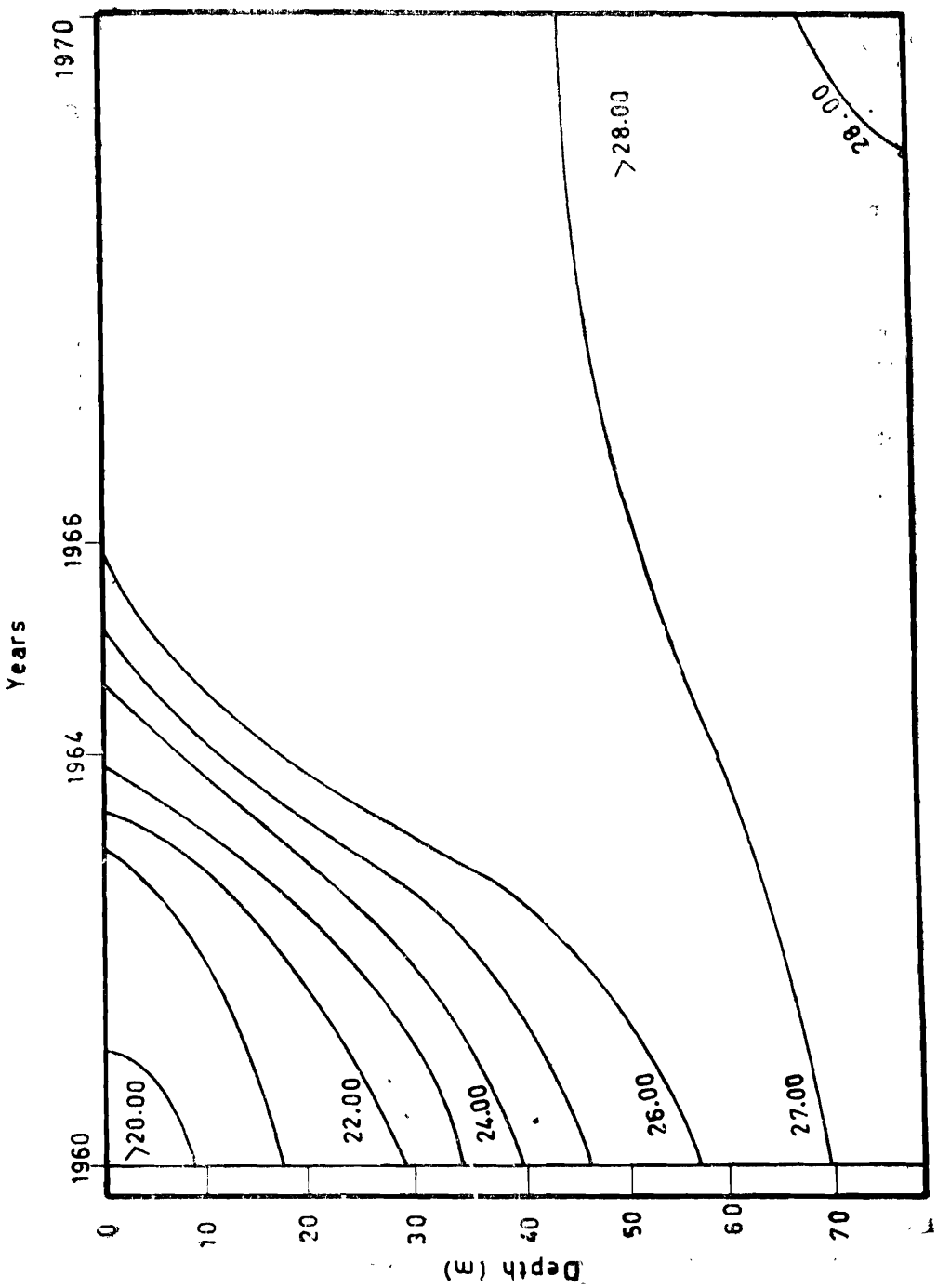

Fig. 2(b). The distribution of σ-(Sigma-t) isolines with depth in the region 20–30 miles North to the Rosetta outlet during autumn 1960, 1964, 1966 and 1971.

ward flow of the Mediterranean surface water curent in the south eastern regions affected considerably the distribution of salinity in the before mentioned regions. The flowing path of the mixed Nile and sea water was usually directed to the North-east then estwards from the Rosetta outlet.

Gorgy (1966), Halim *et al.*, (1967) and Rjonsnutsky (1970) have investigated the hydrological conditions of the southeastern Mediterranean waters in the years 1961, 1964 and 1966 successively. However a need is aroused to study the rate of change of salinity and σ_t (Sigma-t) conditions of the waters North to the Nile delta during the successive years 1960-1971, in a trial to explain the corresponding change in the abundance of marine organisms. The salinity and σ_t (Sigma-t) changes which took place, in the above mentioned regions after the construction of the Aswan High Dam could be identified from Figs. 1, 2_A , 2_B). They show the change in the distribution of the isohalines and the (Sigma-t) isolines in hydrographic stations at about 30-50 miles North to the Rosetta outlet during the years 1960, 1964, 1966 and 1971.

The effect of Nile discharge was highly significant in the period before 1965. This effect was clear in the water layers from the surface to about 50-75 m depth. The minimum salinity, in the regions at about 25-30 miles north to the Rosetta outlet, was within the range of 26.24-29.85‰. This minimum salinity values were characteristic of the upper-most surface water layers during the flood season of the river. The salinity was observed to increase gradually with depth. It reached a value of about 35.00% at the 50 m depth. Under this depth, the salinity varied within the range 38.18-38-86‰. The shallow water regions of less than 50 m. depth were the field of intense diluting effect by the outflowing Nile water.

The distribution of salinity in the year 1966 show an abrupt increase in its value all over the continental shelf. The salinity gradient by time was clearly significant during the year 1965. Since 1966, the salinity of the surface water varied between 39.27 and 39.40‰. In Fig. (2 A) the isohalines 38.50 and 39.00‰ indicates that the upper diluted water volumes occupying the levels of 0-75 m depth, in the period before the year 1965, were displaced in 1966 by water volumes of higher salinity. The minimum salinity of the near-shore waters after 1966 was 38.86-38.96‰. These values were observed in the regions which do not exceed 15 m depth. The start of recent salinity increase was the result of the decrease in the dischanrge of Nile and lake

waters to about 11.3 km³ in 1966. The bottom water layers in the shallow regions is recently estimated to attain an average salinity 39.31‰. Exceptions could be found in restricted areas round the lake-sea connections.

It is obvious that the water masses which existed in the continental shelf regions during the years before 1965, have been changed. The low salinity and significantly fertile mixed water mass of the uppermost layers almost disappeared and were substituted by the highly saline less fertile water mass of the upper layers from the open Mediterranean Sea (Fig. 2_A, 2_B). The density distribution may indicate the effect of the processes which determine the fertility of sea water. The uppermost water masses which spreaded in the 0-50 m layers of the nearshore regions before the year 1965, were of lower σ_t (Sigma-t) values (20.00-25.00) than the underlying σ_t (Sigma-t) 28.00 of the deeper layers. In consequence an almost vertically stable system was established. The potential fertility of these water masses was significant because of its nature as a resultant of the sea water mixing with the outflowing waters of the Nile. On the contrary, the recently distributed water mass of the upper 0-50 m layers after 1966 is characterised by σ_t (Sigma-t) 26.00-27.00 (Fig. 2 B). In the years 1968-1970 the Nile discharge have been about 4.1 km³ and thus helped the distribution of this water bodies of higher density values. Consequently, an almost homogeneous distribution of the σ_t (Sigma-t) values with depth, as compared with its distribution before 1965, is found to characterise the waters of the continental shelf regions. The water layers which recently attained high salinity and almost homogeneous distribution of density are liable to be affected by the seasonal fluctuations in temperature. The rate of mixing and the convection processes is accelerated by the decrease in the water temperature during the cold winter. The recent observations indicate no signifiacnt compensation of the potential fertility as it could be found from the similar convection processes in the seas.

The annual catch of all the fish species helps to evaluate the change in the fertility of the corresponding fishery grounds. The catch per trip could be considered as an index for this evaluation. Sharp decrease in the fish catch is observed after the year 1965. Consequently the fish catch per trip of the motorised boats decreased from 1.02 ton/trip to 0.45 ton/trip (Tables, 2, 3).

TABLE 2.—THE ANNUAL CATCH OF FISH AND THE NUMBER OF FISHING IPS OF MOTORISED BOATS NORTH TO THE DELAT COASTS.

Year	1962	1963	1964	1966
al catch (ton) . .	37832.2	32909.2	25975.0	24686.4
irg trips	36913	36302	32014	361166
catch/trip . . .	1 02	0.91	.081	0.79

TABLE 3.—THE ANNUAL CATCH OF FISH AND THE NUMBER OF FISHING IPS OF MOTORISED BOATS NORTH TO THE DELTA COASTS.

Year	1966	1967	1968	1969	1970
tal catch (ton)	15045.4	12212.7	13586.3	8520.6	8119.0
shing trips . .	33792	28644	28448	17212	16496
n catch/trip .	0.45	0.43	0.48	0.50	0.45

Nevertheless the annual catch of some marine fishes increased significantly. following study of these fishes could be fruitful:

Fish Species which Tolerate the recent hydrological changes

e Family Mullidae :

This family is represented by the species *Mullus barbatus* (L.) and *Mullus nuletus* (L.). The minimum catch was observed in July and August. It reased gradually from the beginning of November and reached its maximum March (El-Zarka & Koura, 1965). The fishes from the family *Mull-e* were found abundant in the regions north to Abu-Kir Bay during the od season in October, November and December (Gorgy, 1966). They re noticed to migrate during January to the regions located north east to Rosetta outlet. In the period from February to May they increased in ndance especially in the regions having 100-200 m depth.

Before 1965, the fish was usually abundant in the regions of more than 75 m depth. The diluting effect of the Nile water was noted to reach its slightest magnitude at the boundary isoline 38.50‰ of the surface waters layer (El-Maghraby and Halim, 1965). An increase of the captured fish, from the far northern and western regions of the continental shelf infront of the Rosetta outlet and beyond the boundary isolines was frequently noticed and could partially be related to the higher salinity of water in these regions. The distribution of this fish in addition to some other species in the north western part of the Red Sea indicates their tolerance to water masses of salinity reaching 40.21 - 42.45‰ (Demidova and Viskrebeentsv, 1970 ; Kochikov and Bibik, 1970).

Significant decrease in the abundance of fish was observed in the regions of highly diluted or highly saline water types attaining salinities less than 20.0‰or more than 40.5 ‰ (Gorgy, 19866 ; Halim *et al*, 19867).

After 1965, the regions occupied by the water masses which attained salinity about 39.00‰, have greatly increased. The accumulated organic matter, in the bottom sediments from the Nile waters drained during the preceeding years, provided a highly significant feeding base. This probably in the presence of the other favourable hydrological conditions helped the increase in the fish stocks of this family.

Mullus brabatus and *Mullus surmuletus* reproduce in the Gulf of Algeria (Marinaro, 19871). The salinity of the Gulf waters is about 36 58‰. The reproduction takes place in the summer season. The maximum abundance of the eggs in the Gulf waters, was observed in July at a temperature 24.1°c. The reproduction of the *Mullus* species was recorded in the shallow near-shore regions of the Egyptian south eastern part of the Mediterranean Sea in 1966. It began in April and reached its maximum during May and June. August was the end of the spawning season (Pavlovskaya and Budnichenko, 1970). Much lesser rates of dilution of sea water were observed during the spawning in spring.

In 1966, the near-shore waters North to the delta attained salinity 38.00-38.75‰. The water temperature during the late spring and the middle of summer, varied in-between 20.0 and 28.0°c.

Fig. (3a, 5a), show that the total landings of the *Mullus* species from the South eastern waters of Egypt have passed three phases. The first of which

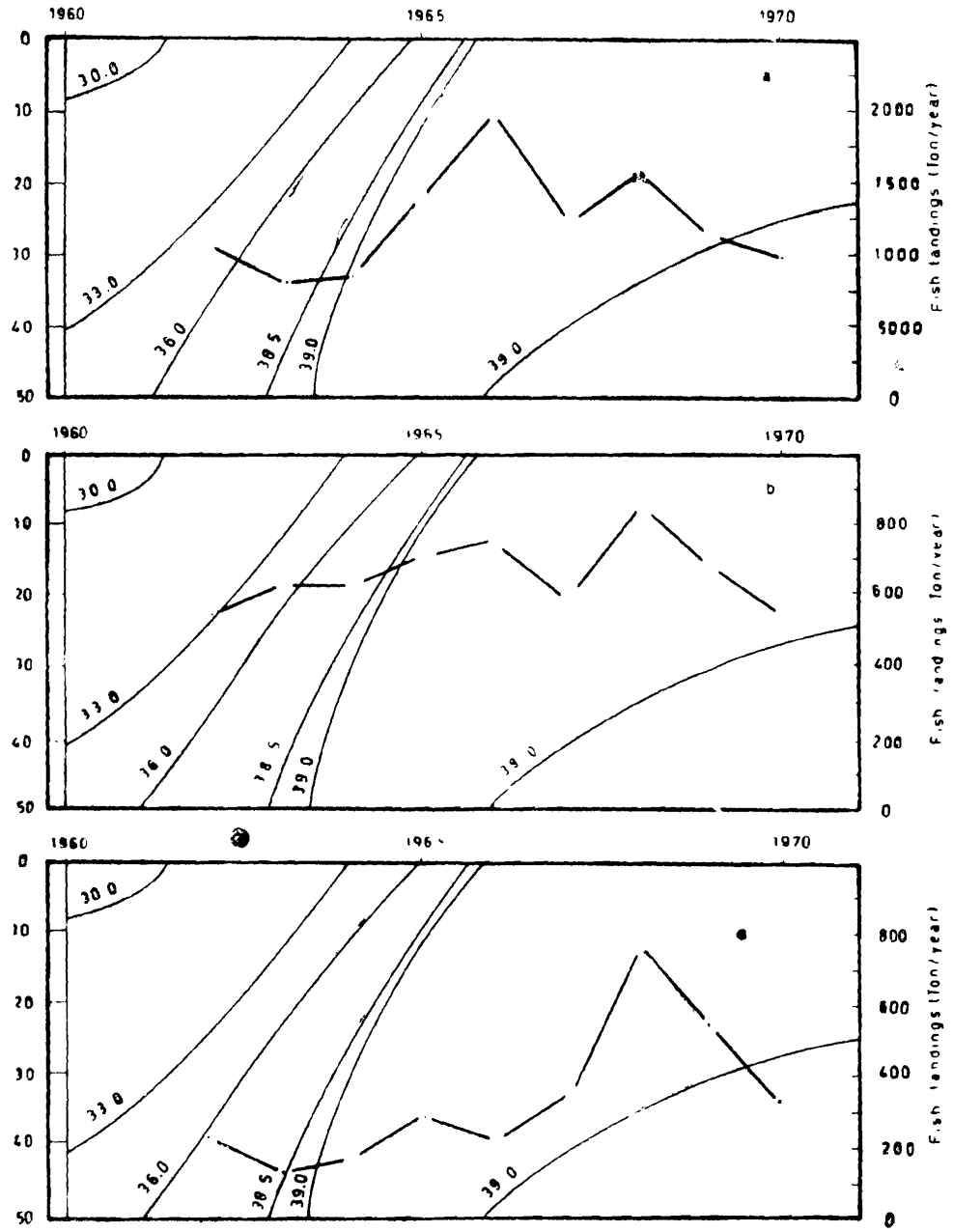

FIG. 3. Salinity — Fish landings association diagram showing the changes in sea water salinity and the fish catch of (*a*) Fam. *Mullidae*, (*b*) Fam. *Pagridae*, (*c*) oam. *Trigliaee*, from the regions of 0–50 m depth North to the Delta shores during the successive years 1960–1970.

is identified during the period before 1965. Before this year, the fish production fluctuated between a maximum of about 1074.0 tons and minimum of 779.0 tons. The second was a transitional phase which coincides with the abrupt change in the hydrological characteristics in between the years 1964 and 1966. In this phase, the fish production increased abruptly from 858.3 tons to 1927.5 tons. The third phase is characterized by fluctuating annual landings of the species at a relatively higher level of fish production than before 1965. The annual catch in 1968 increased to 1523.6 tons. This variation in the fish production indicates that the change in the hydrological characteristics after 1966 was associated with about 2.5 times an increase of its magnitude before 1965.

The Family Pagridae .

This family is mainly represented in the Egyptian waters, by the *Pagrus* and *Pagellus* species. In the years before 1965, this fish formed about 1.4 % of the total catch. In 1966, the observations of the expedition "Ichthyolog" indicated that the maximum abundance of the fish was in the regions of the continental shelf north to the delta coasts between El-Burollus and Damietta outlets (Povlovskaya and Budnichenko, 1970). Important exploitable amounts of the fish were also found in the regions north to Abu-Kir Bay.

The previously observed distribution and abundance of the fish, before the year 1965 in the regions west and north west to the Rosetta outlet, was in relation with the locally dominant proper Mediterranean water of high salinity. The change from the minimum abundance of fish infront of the delta coasts between Rosetta and Damietta outlets before 1965, to a considerable abundance after this year, indicates favourable effect of the decrease in the discharged Nile water and the consequent increase in the salinity of sea water upon the distribution of these species.

In addition, this fish is known to form insignificant constituent of the catches in the North eastern part of the Red Sea. This fact shows that it tolerates salinity of water 40.21 - 42.45‰. However this salinity may be critical for the survival rates of the early stages of fishes. *Pagellus erythrinus* could be found in the coastal regions of higher salinity than 17.70‰ in the north western part of the Black Sea.

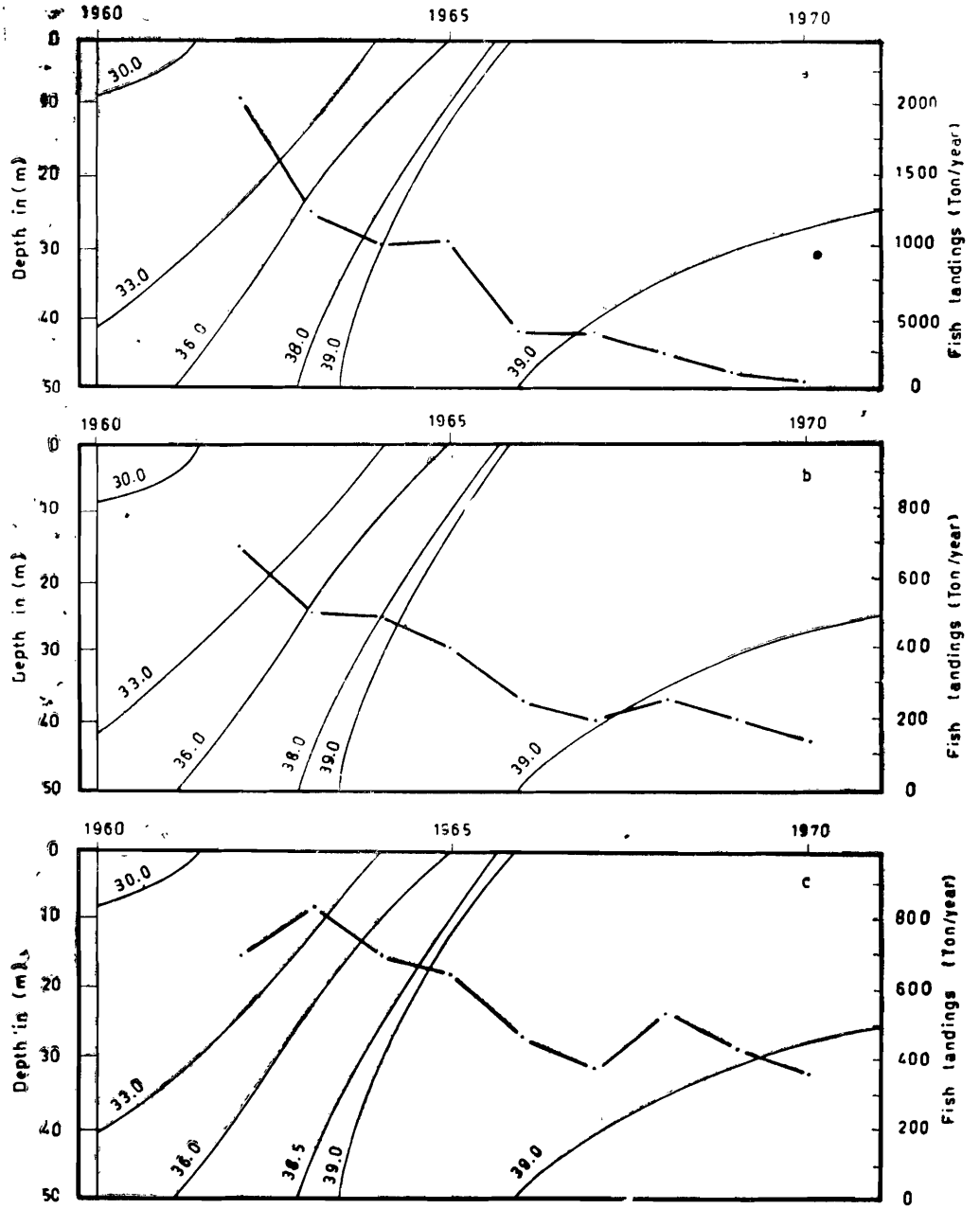

FIG. 4. Salinity — Fish landings association diagrams showing the change in sea water salinity and the fish catch of (*a*) *Sciaeua aquilla*, (*b*) *Solea vulgaris*, (*c*) Fam. *Serranidae*, from the regions of 0-50 m depth North to the Delta shores during the successive years 1960-1970.

Most of the species of this family have pelagic eggs which is undoubtedly affected by the changes in the hydrological conditions. Marinaro (1971) said that the family *Sparidae* reproduces in the Gulf of Algeria. Some of their eggs were abundant in April and May, while the others - in September and October. The salinity of the Gulf waters, which varies inbetween 36.16 - 36.58‰, could therefore be considered favourable for the species reproduction in the spring and autumn seasons.

During the years 1962-1964, average fish landings was 596.2 tons (Fig. 3B, 5B). The following years, 1964-1966, were characterised by an increase in the captured fish from the *Pagrus* and *Pagellus* species. The estimated average of annual landings was 761.8 tons, in the period 1966-1969. The maximum fish catch of the species was observed in 1968. It constituted 1.6 times of the total landings in the year 1962. The increase in the total fish catch since the year 1965, is noticed to be associated with the changes in the hydrological characteristics especially the salinity (Fig. 2B).

The Family Triglidae :

The family constitutes *Trigla gurnardus* (L.) which is widely distributed in the Egyptian waters. The largest amounts of fish were captured during December and January. Gorgy (1966) found that most of the fish attains a length of 15-19 cm and constituted about 11 % of the catch in February-March. The fish distribution was found mostly in the continental shelf regions of 50-100 m depth North to the coasts inbetween Rosetta and Damietta outlets. Considerable increase in the abundance of fish was observed during the winter and spring seasons and could be related to the favourable conditions including the water salinity. The increase in the salinity of sea water usually took place after the end of the flood season. In 1969, the total fish landings of the *Trigla* species, was 216.4 tons. The maximum fish landings were usually recorded in the eastern harbour landing center. It was well known that the trawling boats, from the eastern harbour of Alexandria, used to exploit the fishery grounds North and West to Rosetta outlet of the Nile. The landings of the *Trigla* species in the eastern harbour landing center during the year 1962 reached 178.7 tons. At the same time, the fish landings, in the Damietta center which received the captured fish from the Norh eastern regions infront of the delta coasts, were 25.8 tons. The fishery grounds located inbetween the outlet of Rosetta and the regions North to Alexandria were therefore the main resources of the captured species. The distribution of the *Triglidae* in the regions of 50-100 m depth could be related to the purely marine and stenohaline character of the species. The 50 m isopath was observed to boarder the deeper North and North eastern regions in which the fish was usually found in abundance. The southern regions were the grounds of less abundant fishes of the *Trigla* species.

The favourable salinity of water for the distribution of the family *Triglidae* in the Egyptian waters is mostly 35.00 - 39.00‰. The upper limits of salinity which the family *Triglidae* tolerates are noticed in the North western part of the Red Sea. The fish landings from these regions indicate unsignificant abundance.

The early stages of the family *Triglidae* are pelagic. The fish passes its critical eggs and larvale stages in the uppermost water layers. *Trigla lucerna* in the Algerian Gulf waters reproduce mainly in November, while the eggs of the other *Trigla* species are found in abundance during March. Fig. 3c, 5c show clear association between the increase in the landings in Egypt Mediterranean ports and the recent increase in the salinity and density of water during the period 1965-1968. The average annual catch of the *Trigla* species before the year 1964 was 166.5 tons. The annual variation from the average during this period had not exceeded 51.0 tons. The low salinity could be injuriously effective upon its early stages. The maximum total catch was landed in the year 1968. During the years 1966, 1967, 1968 and 1969, the catch increased sucessively to 1.6, 2.7, 6.1 and 4.4 times its magnitude in 1963. At the same time, the outflowing Nile waters decreased to about 1/3, 1/2, 1/7 and 1/12 its magnitude in 1965. Generally, the landings of the *Trigla* species increased in 1968 to 3.5 times the estimated maximum of annual catches in the period before the construction of the Aswan High Dam.

The beach seine experiments west to lake Idku outlet in November 1971, show that one of the abundant fish in the southern shallow regions of Abu-Kir Bay was the *Trigla* species. These regions were greatly affected, before 1965, by the outflowing drainage and lake Idku waters. In 1964, the mixed waters adjacent to the southern coasts of Abu-Kir Bay attained salinity values inbetween 20.26 and 27.14‰. The fishes of the *Trigla* species were rarely found in these regions during the years before 1965. The captured fishes of the *Trigla* species from the southern shores of Abu-Kir Bay in November 1971, attained lengths which varied inbetween 7 and 11 cm. At that time, the salinity of water was 38.50‰. The recent increase in the salinity of the nearshore waters could be favourable for the distribution and reproduction of the family *Triglidae*.

Fish species which negatively respond to the recent hydrological changes

The group of fish species as *Sciaena aquilla* (Risso), *Solea vulgaris* (L), *Epinephelus species, Temnodon saltator* (Cuv.), have pelagic eggs and larvae and economic significance. Highly significant decrease in their abundance and landings is recently noticed.

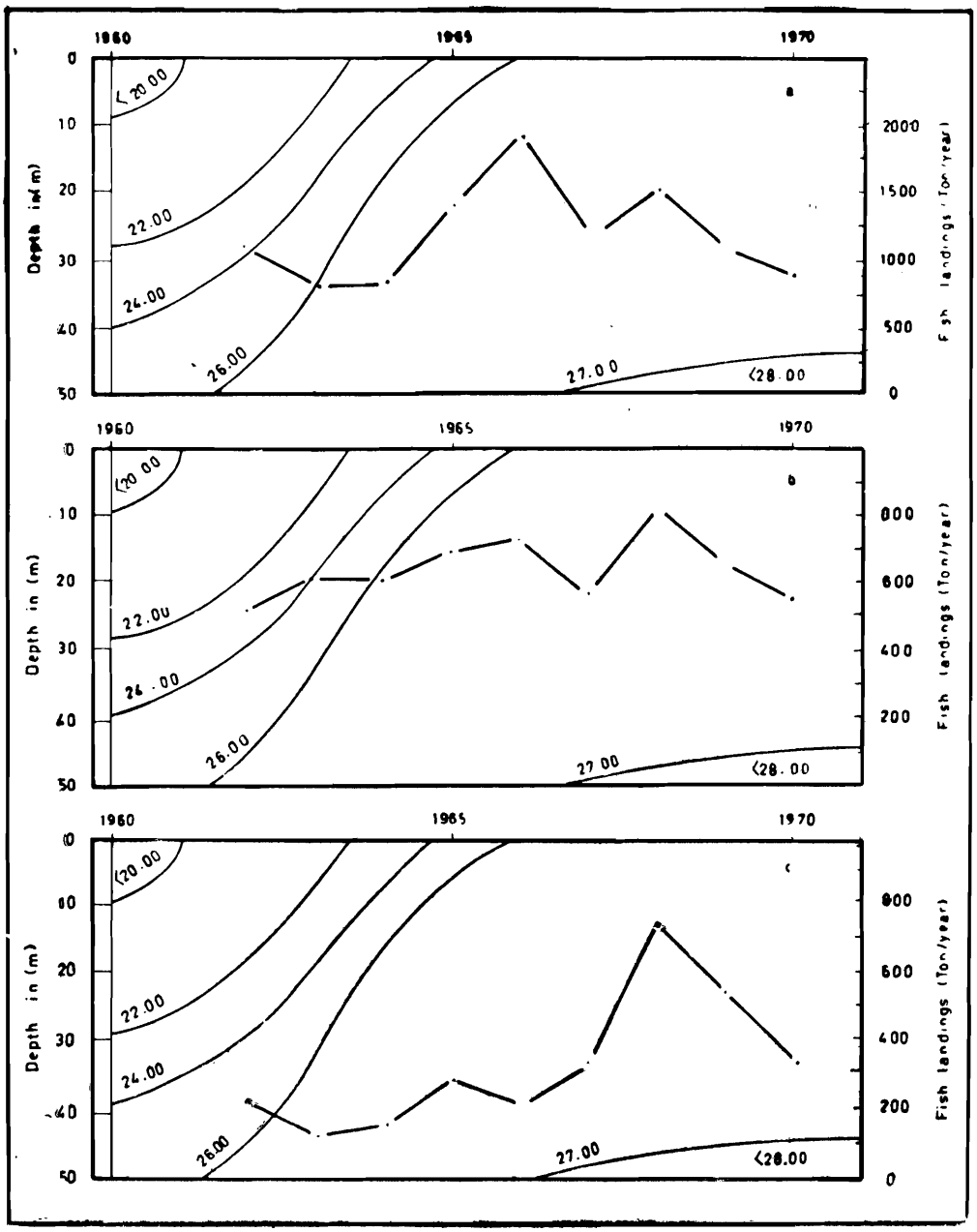

FIG. 5 σ- (Sigma-t) — Fish landings association diagrams showing the change in sea water of σ_t (Sigma-t) and the fish catch of (*a*) Fam *Mullidae*(*b*)Fam.*Pagridae*, (*c*) Fam. *Triglidae*, from the regions of 0-50 m depth North to the Delta shores during the successive years 1960-1970.

Sciaena aquilla (Risso):

The species *Sciaena aquilla* (Risso) was one of the major constituents of the trawler's catch in the shallow water regions of Egypt. El-Zarka and Koura (1965) noted that the fry and adult fish enter the brackish lake waters for feeding through the lake-sea connections. The spawning migration of the fish used to take place from the lakes to the sea during October, November and December. The largest part of the catch of *Sciaena aquilla* was captured during the spawning season from the shallow water regions west of the Rosetta outlet of the Nile. The diluted coastal waters in the regions especially of 15-50 m depth adjacent to the outlets of Lake Burollus and Lake Manzala were also grounds of distribution of the fish Gorgy, 19866). Fish attaining 6 to 8 cm modal length appeared in the catches in September and October 1960 (Rafail, 1971).

The eggs of the family *Sciaenidae* are rarely found in the sea water of high salinity. Marinaro (1971) said that the eggs of this family could not be found in the Gulf of Algeria. Therefore the limits of salinity tolerance of the small fish may differ greatly from 36.16‰.

In November 1964, the mixed sea water of Abu-Kir Bay which was adjacent to Lake Edku outlet attained salinity values less than 24.00‰. The salinity of the brackish water in the regions of the lake which are adjacent to its outlet varied between 0.95 and 9.28‰ in November 1963. The annual catch of this species in the year 1964 was estimated to be 309.1 tons from the centers of Abu-Kir Bay and the lake-sea connection. The total landings of the fish from the same regions during the year 1968 were about 38.7 tons only. This show a decrease of about 1/8 times the previously observed production of fish in 1964. The recent decrease in the catch is undoubtedly related to the change in the hydrological conditions. The salinity of the southern near-shore waters of Abu-Kir Bay was found not less than 38.50‰ in November 1971, and increase seawards. A restricted zone at the western shores of Abu-Kir Bay is the field where industrial waste water are discharged. The increase in the abundance of some fishes of other species as from the family *Triglidae* rejects, at present, the probability of significant destructive effect of pollution upon the fishes.

The landings of *Sciaena aquilla* from the Egyptian shore waters were of the maximum magnitude in 1962 (Fig. 4a, 6a). During the years 1962-1965, the annual catch decreased from 2185.0 tons to 1048.4 tons. The fish catch was observed to reach 90.4 tons in 1970.

The observed differences in the outflowing Nile water probably affected the total catch of the family *Sciaenidae*. Since the year 1965, gradual and continuous decrease in the fish landings was recorded. (Fig. 4 a).

Solea vulgaris :

The annual fish production of *Solea vulgaris* (L.) in the period before 1965, constituted about 1.8 % of the total catch. The largest percentages of fish were recorded in the regions of 15-100 m depth to the west of Rosetta outlet and in the regions 15-50 m depth east to Damietta outlet (S. Gorgy, 1966). The fishery grounds between Rosetta and Damietta outlets were characterised by slightly less landings of this species than the other regions. The largest amounts of fish were landed during the winter and early spring seasons. The maximum catch was mostly recorded in January. The minima of captured fish were landed in August, September and October.

Since the year 1938, the *Solea vulgaris* was transplanted successfully in the inland saline Lake Quarun. The salinity of the lake increased from 19.42‰ in 1934 to 25.0 - 29.0 ‰ in 1959. In the years 1961 and 1962, the fish production of this species from lake Quarun exceeded that from the Egyptian continental shelf of the Mediterranean Sea. The area of the lake is significantly less than that of the fishery grounds infront of the delta coasts. Apparently, the range of salinity 25.00 - 29.00‰ is highly favourable to the distribution and reproduction of *Solea vulgaris*.

The eggs and larvae of *Solea lascaris* (Pallas) were recorded in the waters of the North western part of the Black Sea, where the salinity was 14.00 - 16.09‰. This suggests that the lower limit of salinity tolerance of this species may not differ significantly from 14.00‰.

During the months April-September, the eggs of the family *Soleidae* could be found in abundance in the Gulf of Algeria waters. The spawning of *Solea vulgaris* in the Egyptian waters extends from December to the early spring and reaches its maximum during January - February.

The higher salinity values influence which may limit the distribution and reproduction of *Solea vulgaris* may be detected by the comparison of the fish catch in 1962 from the North western part of the Red Sea with its landings in the same year from the fishery grounds infront of the Nile delta. The total fish landings from the North western part of the Red Sea were 2.0 tons, while the total landings from the fishery grounds in the Mediterranean Sea

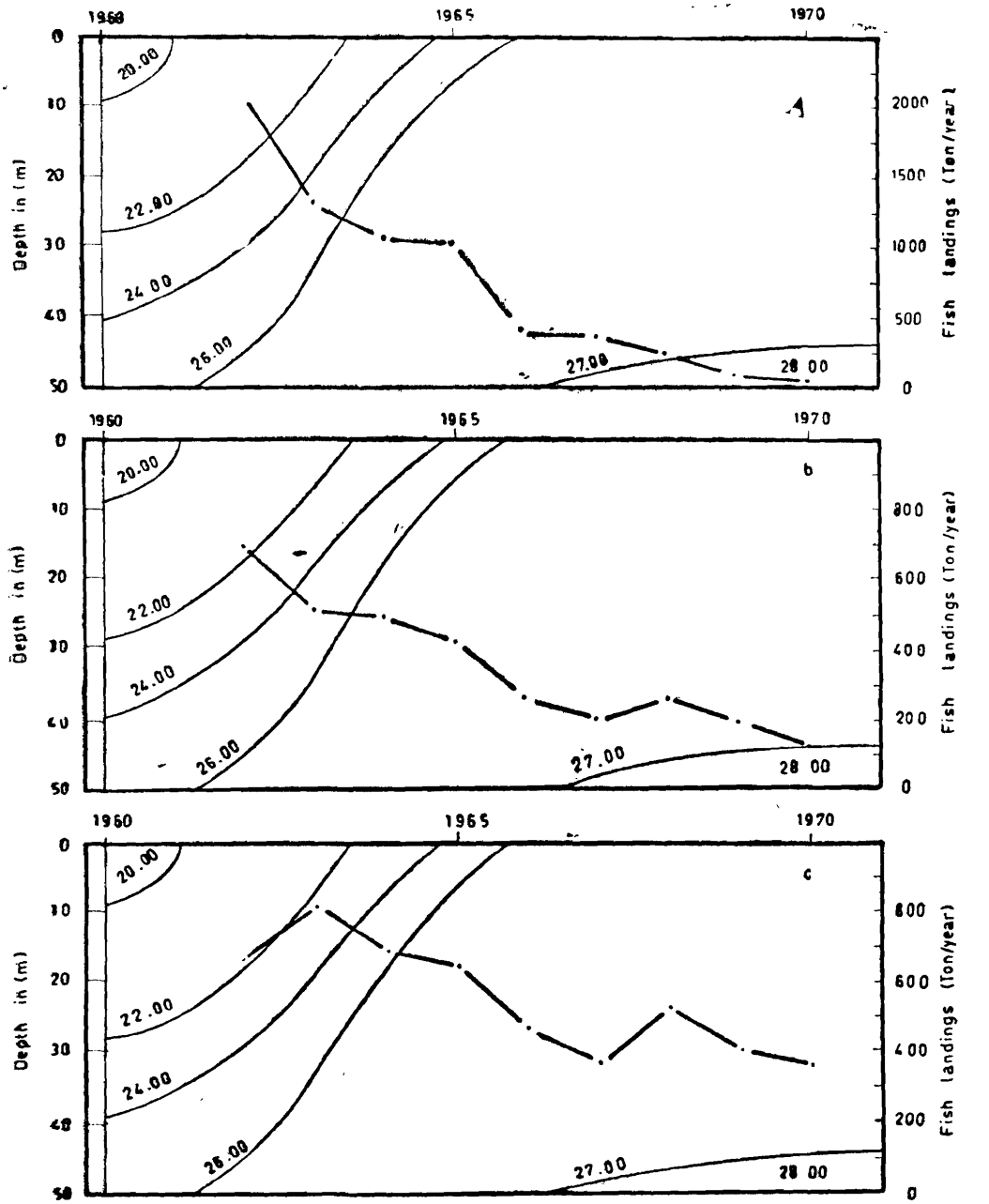

Fig. 6. σ- (Sigma-t) — Fish landings association diagrams showing the change in sea water of σ- (Sigma-t) and the fish catch of (*a*) *Sciaena aquilla*, (*b*) *Solea vulgaris*, (*c*) *Family Serranidae*.

reached 695.2 tons. The salinity limits of tolerance of the family *Soleidae* is suggested not to differ significantly from 14.00‰ for the lower limit and 42.15‰ for the higher limit. The most favourable condition of salinity for the distribution and reproduction of *Solea vulgaris* in the Egyptian waters could be considered within the range 25.00 - 36.50‰

The highest annual catch was landed in 1962. During the years 1963, 1964 and 1965 the annual fish production was nearly identical. Its average annual catch was about 526.2 tons. The captured fish during the years 1966, 1967, 1968 & 1969 decreased considerably from the average annual catch at the period before the recent decrease in the outflowing Nile waters (Fig. 4b, 6b). The annual catch was observed to decline from 504.6 tons in 1964 to 255.4 tons in 1966, which suggests a transitional phase as a result of the effect of the abrupt change in the hydrological conditions. After the year 1966, the average annual fish catch was 232.1 tons. The maximum variation from the average have not exceeded 36.4 tons. The slight fluctuations of the fish landings after the construction of the High Dam show a nearly stable level of production which is less than that observed before the year 1966. The decrease of the captured amounts of fish during the year 1967 was not considerably great as it was expected because of the war time. Since 1966, the annual catch was about ½ of the estimated average before the year 1965.

The Family Serranidae :

This family includes economically important group of fishes especially the *Epinephelus* and *Serranus* species. According to El-Zarka and Koura (1965) the annual catch of *Serranidae* varied in the different regions of the Egyptian waters showing a trend to decrease eastwards. The least amounts of captured fish were landed from the eastern regions. Marked increase was frequently observed in the spring season and reached its maximum in May.

The pelagic eggs and larvae of *Serranus caprilla* and *Serranus scriba* were found in abundance during May, June and July in the Gulf of Algeria (Marinaro, 1971). *Serranus caprilla* and *Serranus Scriba* were distributed in the waters of the western Egyptian coasts of the Mediterranean Sea. The dominant species in the eastern regions of the continental shelf are the *Epinephelus gigas* (C.) and *Epinephelus alexandrinus* (C.) (Gorgy, 1966 and Rafail *et al.* 1969). The water masses west and North west to Alexandria coasts in which the *Serranus* species propagates, were away from the mixing and diluting effect of the Nile waters. These regions attained salinity 38.6 — 39.00‰ In the eastern regions, especially beyond several kilometers of the Nile outlets, the salinity varied inbetween 14.0-19.0%. The *Epinephelus* species were noticed to be abundant in the eastern regions of 50-100 m. depth.

The abundance of the *Epinephelus* species in the eastern regions and the *Serranus* species in the west indicate a difference in the species tolerance to the salinity of water.

The eastern fishery grounds of the Egyptian waters were the main productive regions to the *Epinephelus* species during the period before 1965. The maximum annual catch of the fishes from the family *Serranidae* was estimated in the year 1963 to be 824.4 tons. The average annual landings during the years 1962-1965 were 711.6 tons. The annual fish production in the years 1962-1964 had not exceeded a difference of about 19.8 tons from the average. After the decrease in the volum of outflowing Nile waters in 1965, the annual fish catch decreased considerably (Fig. 4c, 6c). During the years 1966-1969, the annual catch reached an average of 458.9 tons. This show that the abundance of fish before the change in the water masses was about 1.5 times its magnitude after it. The total catch during the years of war in 1967 was of minimum magnitude. The estimates of the annual catch of the family *Serranidae* show general trend to decrease in association with the recent changes of the hydrological conditions in the south eastern Mediterranean Sea waters.

SUMMARY

1. The salinity of the water volumes in the regions of about 75 m depth North to the eastern Egyptian coasts of the Mediterranean Sea have recently changed from the range of 26.24-38.86% to 38.86-39.40% as a result of the decrease in the discharged Nile waters during the autumn season.
2. The abrupt decrease of the Nile discharge from 39 km^3 in 1965 to 11.3 km^3 in 1966 and 4.1 in 1970, resulted the nearshore surface waters of σ_t (Sigma-t) 20.00-25.00 to be abruptly displaced at the end of 1966 by sea water of σ_t (Sigma-t) 26.00.27.00.
3. The diluted water regions have been restricted to the zones of the lake-sea connections.
4. Some fish species which were abundant and reproduced in the diluted waters of the shallow regions have shown a recent decrease in their landings.
5. On the other hand, the fish species which have pelagic early stages and have affinity to the water of higher salt content appear more abundant in the landings than before.
6. The range of salinity tolerance of the different stages of the fish is determining to the species distribution, reproduction and abundance in the fishery grounds.

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